Small Business Innovation Research (SBIR) and
Small Business Technology Transfer (STTR)
Opportunity Announcement
HR001120S0019-08
Near-Term Forecasting of Nonstationary Dynamic Processes

Which program will fund this topic?
SBIR
What type of proposals will be accepted?
Both Phase I and Direct to Phase II (DP2)

Technology Area(s): Biomedical, Information Systems

I. INTRODUCTION

The Defense Advanced Research Projects Agency (DARPA) Small Business Programs Office (SBPO) is issuing an SBIR/STTR Opportunity (SBO) inviting submissions of innovative research concepts in the technical domain(s) of Biomedical, Information Systems. In particular, DARPA is interested in understanding the feasibility of Near-Term Forecasting of Nonstationary Dynamic Processes.

This SBO is issued under the Broad Agency Announcement (BAA) for SBIR/STTR, HR001120S0019. All proposals in response to the technical area(s) described herein will be submitted in accordance with the instructions provided under HR001120S0019, found here: https://beta.sam.gov/opp/b8abeb02f16a4450b2c2f859fc00c177/view.

a. Eligibility

The eligibility requirements for the SBIR/STTR programs are unique and do not correspond to those of other small business programs. Please refer to Section 3.1, Eligible Applicants, of HR001120S0019 for full eligibility requirements.

b. Anticipated Structure/Award Information

Please refer to Section 1, Funding Opportunity Description provided in HR001120S0019 for detailed information regarding SBIR/STTR phase structure and flexibility.

If a proposer can provide adequate documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of the topic has been met and describes the potential commercial applications, the Direct to Phase II (DP2) authority allows the Department of Defense (DoD) to make an award to a small business concern under Phase II of the SBIR program without regard to whether the small business concern was provided an award under Phase I of an SBIR program. This SBO is accepting DP2 proposal submissions.

For this SBO, DARPA will accept Phase I proposals for cost of up to $120,000 for a 6-month period of performance.

DARPA will accept DP2 proposals for cost of up to $1,750,000. This includes a 24 month base period not to exceed a cost of $1,000,000 and a 6-month option period not to exceed a cost of $500,000. A separately priced option of up to $250,000 must also be proposed for contractors who would like to be considered for participation in the DARPA Embedded Entrepreneur Initiative (EEI). Refer to Section 2.6, DARPA Embedded Entrepreneur Initiative, of HR001120S0019 for detailed information on EEI.

Proposers should refer to Section 4, Application and Submission Information, of HR001120S0019 for detailed proposal preparation instructions. Proposals that do not comply with the requirements detailed in HR001120S0019 and the research objectives of this SBO are considered non-conforming and therefore are not evaluated nor considered for award.

Phase I proposals shall not exceed 20 pages. Phase I commercialization strategy shall not exceed 5 pages. This should be the last section of the Technical Volume and will not count against the 20-page limit. Please refer to Appendix A of HR001120S0019 for detailed instructions on Phase I proposal preparation.

DP2 Feasibility Documentation shall not exceed 20 pages. DP2 Technical Proposal shall not exceed 40 pages. Phase II commercialization strategy shall not exceed 5 pages. It should be the last section of the Technical Volume and will not count against the 40-page limit. Please refer to Appendix B of HR001120S0019 for detailed instructions on DP2 proposal preparation.

c. Human Subjects Research (HSR)/Animal Use

Proposers that anticipate involving Human Subjects Research or Animal Use must comply with the approval procedures detailed at http://www.darpa.mil/work-with-us/additional-baa. For more information, refer to Section 4.7, Human Subjects/Research/Animal Use, of HR001120S0019.

Proposers are highly encouraged to clearly segregate research tasks from human and/or animal testing tasks to allow for partial funding while internal and DoD approvals are being obtained.

d. Evaluation of Proposals

Section 5, Evaluation of Proposals, in HR001120S0019 provides detailed information on proposal evaluation and the selection process for this SBO.

e. Due Date/Time

Full proposal packages (Proposal Cover Sheet, Technical Volume, Price/Cost Volume inclusive of supporting documentation, and Company Commercialization Report) must be submitted via the DoD SBIR/STTR Proposal Submission website per the instructions outlined in HR001120S0019 no later than **2:00pm ET, June 29, 2020.**

II. TOPIC OVERVIEW

a. Objective

Develop methodologies for accurate prediction of nonstationary processes based on a limited-amount of observational data.

b. Description

Techniques for predicting behaviors of complex stochastic dynamical systems often rely on longitudinal observation data over a sufficiently long time horizon. These techniques assume that the underlying dynamical processes are statistically stationary. However, many sudden crises/events such as the current COVID-19 pandemic involve fast-evolving dynamics that are highly nonstationary, with complex feedbacks (e.g., due to non-uniform local intervention ranges) and sudden phase shifts (e.g., new unexplained COVID-19 hotspot regions). When dealing with such rapidly developing situations, decision makers need tools capable of making near-term event predictions to inform critical decisions. For example, in the current COVID-19 pandemic there is a need for government officials to predict the expected number of COVID-19 patients requiring hospitalization in all regions to inform the distribution of medical resources.

This SBIR effort will explore analytic techniques that can make accurate short-term predictions of rapidly developing nonstationary dynamical systems. The focus will be on the ability to provide useful information to operators at the onset of a crisis when little or no historical data is available and/or when strong feedback/intervention renders historical data ineffective. DARPA is interested in developing analytic tools that can provide the following capabilities: 1) ability to make accurate predictions of rapidly unfolding complex dynamical processes based on direct, local observables, over a short time-scale, without relying on extensive collateral data repositories; 2) ability to identify the time-scale and spatial range over which such predictions are valid; and 3) ability to detect bifurcations in dynamical behaviors, that is, when the underlying dynamical system shifts between dynamics of different types.

c. Phase I

Develop a prototype algorithm(s) for forecasting nonstationary time-series from limited observational data. Phase I research will develop the basic algorithms and establish the technical feasibility of the proposed prediction approach using real-world test data. Specifically, DARPA is interested in using the unfolding cases of COVID-19 as experimental data to demonstrate the ability of the proposed approach to forward predict, in real-time, the evolution of COVID-19 over the time horizon of a few days with high-accuracy (<10% deviation from actuals) relative to new cases as well as both current hotspot spread and the ability to identify emergent hotspots, i.e., regions not previously affected by the virus (phase shifts).

Schedule/Milestones/Deliverables

- Month 1: Report on initial algorithms approaches, detailed research and development plan, detailed experiment plan.
- Month 3: Interim report describing preliminary performance of the prototype algorithms
- Month 6: Final Phase I Report summarizing approaches; prototype algorithms; experimental results; comparison with alternative state-of-the-art methodology; quantification of model prediction accuracy

d. Phase II

Demonstrate the operational utility of the forecasting analytics in real-world applications. Phase II research will enhance the capabilities of the forecasting algorithm(s) developed in Phase I and mature the analytics into automated tools. The automation should include the ability to determine the time-scales and spatial ranges over which predictions are possible, to monitor the switch between different dynamical regimes and to quickly adapt to new dynamics following phase shift events. Phase II research will establish performance bounds on the predictive capabilities and limitations as a function of time-scales and the availability of observations. Phase II research will demonstrate, via a case study, the potential of the proposed techniques to improve decision making in response to nonstationary dynamical events. Examples of such case studies include the coupling of forecasts to capacity monitoring of medical treatment facilities and medical supply stocking for the ongoing COVID-19 pandemic. Other use cases may be proposed by the proposers. Proposals should include specific performance metrics to demonstrate the operational benefits of proposer's forecasting analytics compared with the state of the art. In particular, Phase II proposals should describe how the proposed approach will operate over nonstationary dynamic events with multiple (>3) transitions, rapid adaptation to dynamic transitions (delay of <3 input data cycles), and <1% prediction error. Phase II performer(s) will also develop software applications with a user-friendly interface. It is expected that deliverables from Phase II will include an application software prototype that can be deployed in field experiments for further evaluation. DARPA desires open-source software. In the optional phase, the performer is also expected to demonstrate the ability to adapt its Phase II algorithms to a second, new case study.

Schedule/Milestones/Deliverables

- Month 1: Report providing an updated research and development plan based on the Phase I research outcome and PM feedback, Phase II experiment evaluation plan
- Month 3: Report on enhancement of algorithms and approaches, expanded capabilities, updated performance of the prototype algorithms
- Month 6: Interim report providing preliminary analysis on the expected advantages of the approaches over the current state-of-the-art
- Month 9: Report on initial implementation of the case study application software, acquisition of data sets for Phase II case study

- Month 12: Mid-term report updating the algorithms approach, comprehensive performance analysis, description of the application prototype software design, proposed evaluation metrics, initial experiment results and analyses
- Month 15: Report describing the updated implementation of the application software prototype, updated experiment results, revised quantification of the performance
- Month 18: On-site demonstration of the application prototype
- Month 21: Report providing updated description of the application demonstration prototype, updated quantification of the algorithm performance
- Month 24: Final Phase II report documenting the computation theories and models, application demonstration design and implementation, experiment results and performance analysis, analysis of the scalability of the performance observed in the prototype, comparison against state-of-the art, and plan for optional phase development and plan for the second case study
- Month 27: Application software prototype revision release, preliminary experiment results for the second case study and performance quantification
- Month 30: Report documenting the final application software prototype, and plan for commercialization

e. Dual Use Applications (Phase III)

The Phase III effort should expand the application demonstration developed in Phase II to a wide range of operational use cases, including both commercial and DoD applications. A commercially-focused Phase III application could include the development of supply monitoring applications for shops to monitor their merchant supplies in times of crisis or a smartphone application for the general public for timely alerts of local hotspots. Examples of Phase III DoD applications could include development of early warning systems for rapidly developing events of national security interest or the coupling of forecast analytics to DoD logistics management systems to enable enhanced handling of nonstationary inputs. The Phase III effort should provide advanced tools and software.

f. References

[1] Maimaiti, M., et al. "A Deep Learning-Based Approach to Forecast the Onset of Magnetic Substorms." Space Weather 17.11 (2019): 1534-1552.

[2] Lazer, David, et al. "The parable of Google Flu: traps in big data analysis." Science 343.6176 (2014): 1203-1205.

[3] “Why It’s So Freaking Hard To Make A Good COVID-19 Model”, https://fivethirtyeight.com/features/why-its-so-freaking-hard-to-make-a-good-covid-19-model/

[4] Luan, Shenghua, Jochen Reb, and Gerd Gigerenzer. "Ecological rationality: Fast-and-frugal heuristics for managerial decision making under uncertainty." Academy of Management Journal 62.6 (2019): 1735-1759.

[5] Hogg, James, et al. "Koopman Mode Analysis of agent-based models of logistics processes." PloS one 14.9 (2019)

g. Keywords

Dynamical system prediction, nonstationary systems, time series forecast, model shift, COVID-19 pandemic modeling

III. SUBMISSION OF QUESTIONS

DARPA intends to use electronic mail for all correspondence regarding this SBO. Questions related to the technical aspect of the research objectives and awards specifically related to this SBO should be emailed to HR001120S0019@darpa.mil. Please reference BAA HR001120S0019-08 in the subject line. All questions must be in English and must include the name, email address, and the telephone number of a point of contact.

DARPA will attempt to answer questions in a timely manner; however, questions submitted within seven (7) calendar days of the proposal due date listed herein may not be answered. DARPA will post a consolidated Frequently Asked Questions (FAQ) document. To access the posting please visit: http://www.darpa.mil/work-with-us/opportunities. Under the HR001120S0019-08 summary, there will be a link to the FAQ. The FAQ will be updated on an ongoing basis until one week prior to the proposal due date.

In addition to the FAQ specific to this SBO, proposers should also review the SBIR/STTR General FAQ list at: http://www.darpa.mil/work-with-us/opportunities?tFilter=&oFilter=29934. Under the HR001120S0019 summary, there is a link to the general FAQ.

Technical support for the Defense SBIR/STTR Innovation Portal (DSIP) is available Monday through Friday, 9:00 a.m. – 5:00 p.m. ET. Requests for technical support must be emailed to DoDSBIRSupport@reisystems.com with a copy to HR001120S0019@darpa.mil.